Potential impacts of tropical cyclone inner-core moisture initializations on the predictability of the onset of tropical cyclone rapid intensification

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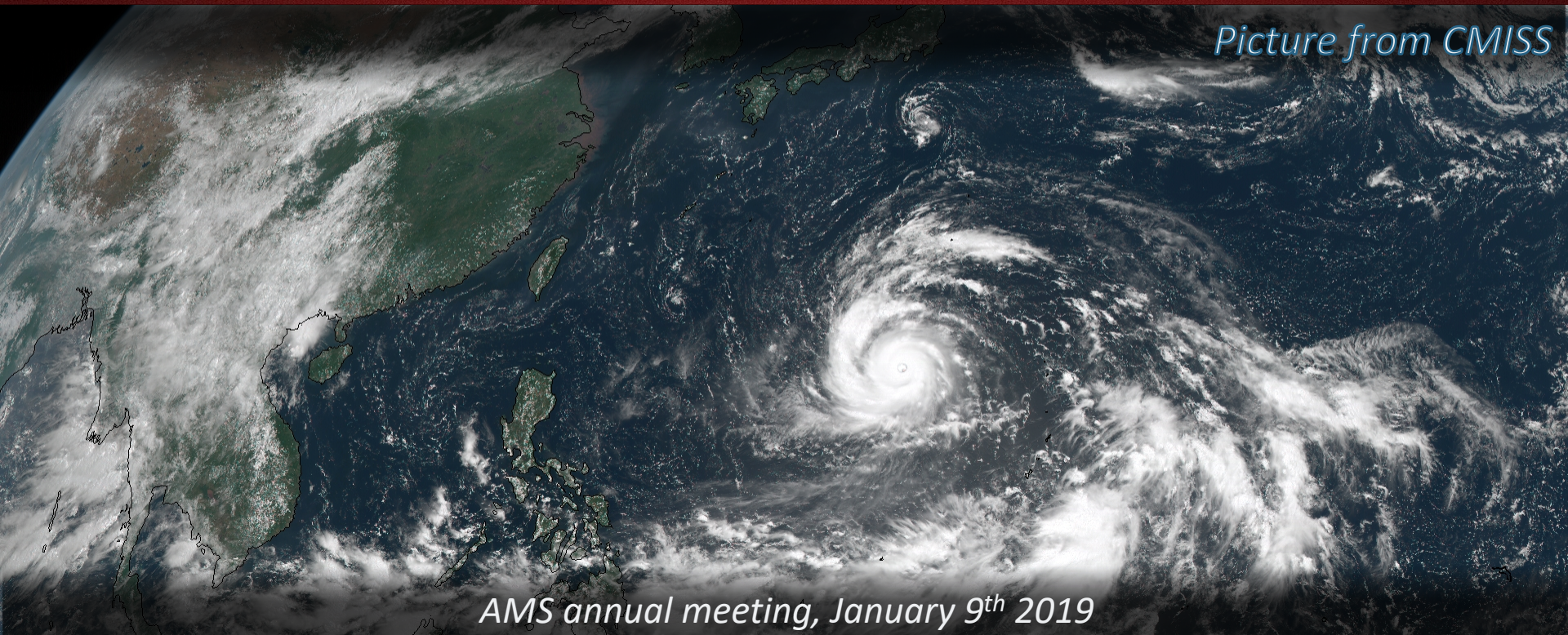


AMS annual meeting, January 9th 2019

Predictability of TC rapid intensification

Precession process: before the onset of rapid intensification

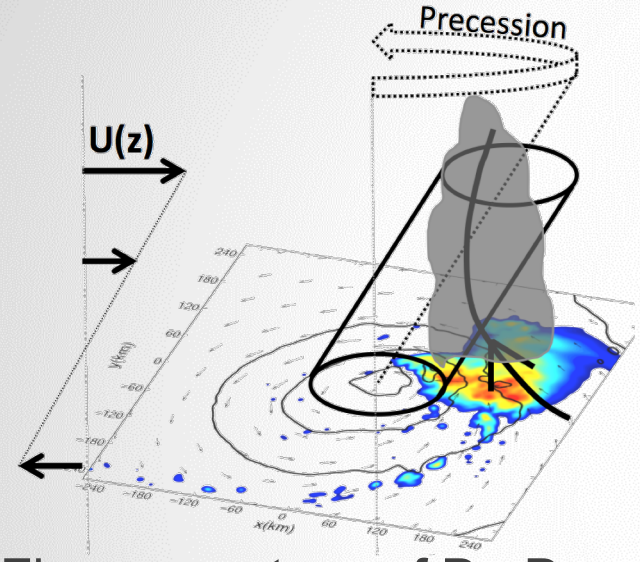
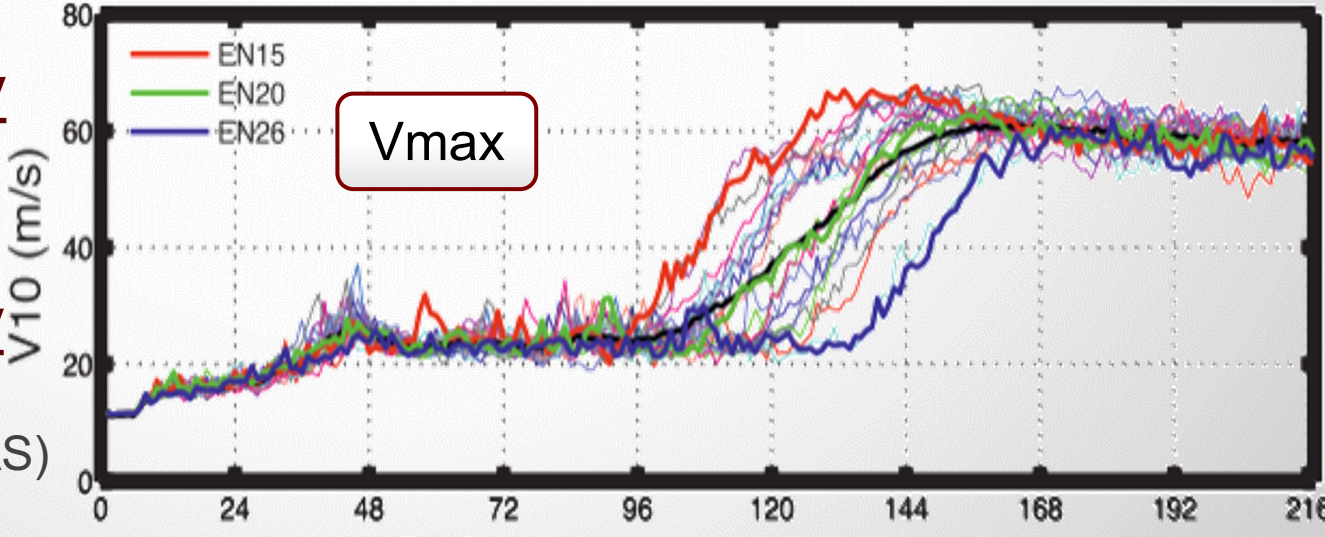


Figure courtesy of Dr. Dandan Tao

- Qualitative evidences of precession process have been reported:
  - Observational
  - Numerical modeling
- The magnitude of precession process were reported to be dominated by **the chaotic nature of moist convections**.

Ensemble sensitivity of RI on initial tiny moisture uncertainty

(Zhang and Tao, 2013, JAS)

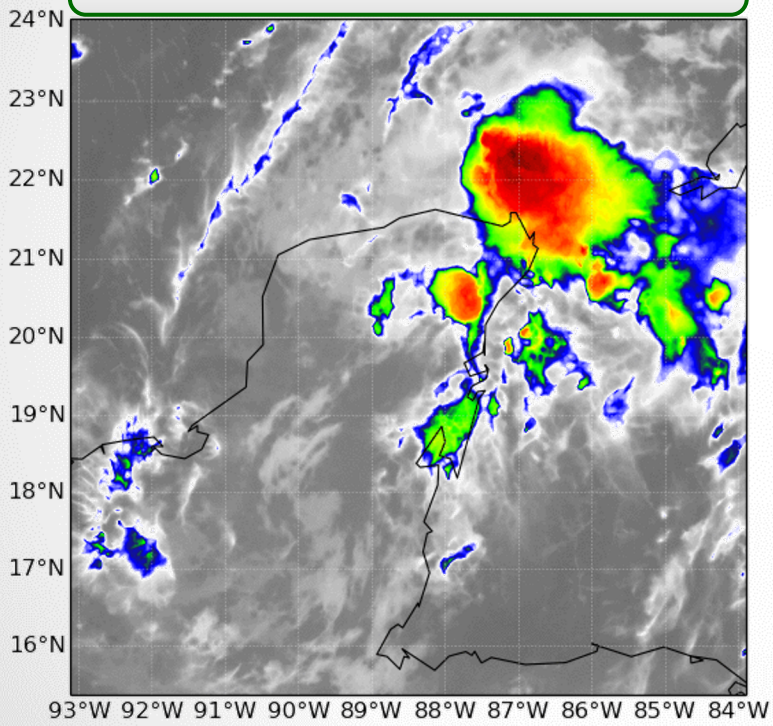


New Satellites! Himawari-8 AHI & GOES-16 ABI

- **Himawari-8 (Nov. 2014)**
- **GOES-16 (Nov. 2016)**

- Frequency: **10-15 minutes**
- Resolution: **2 km**

GOES-16 obs.



Window channel (ch14) image of Hurricane Harvey (2017) monitored by GOES-16 ABI

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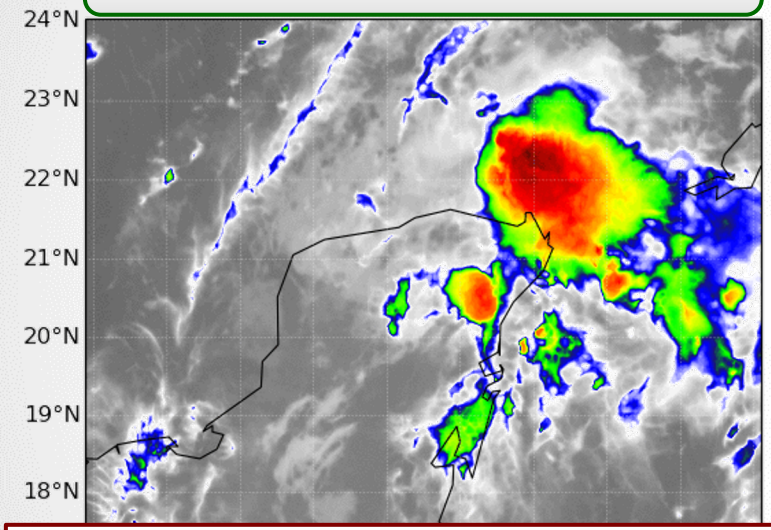
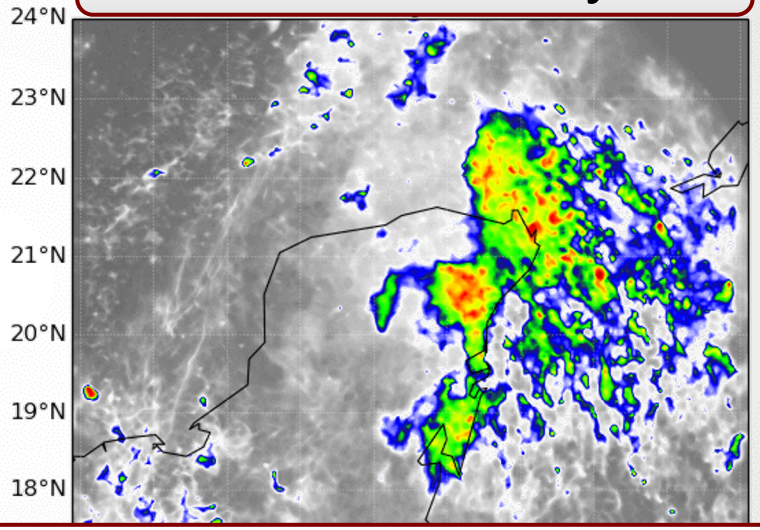
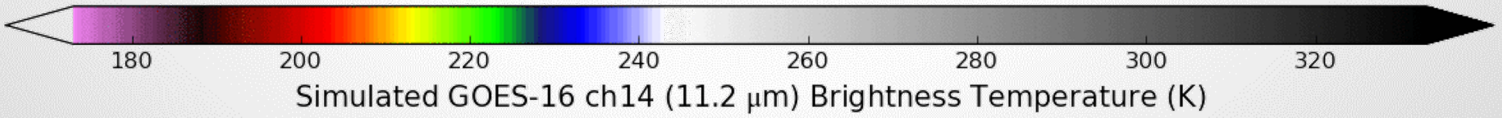


PSU EnKF analysis



How much can these **constrained convective activity** contribute to the **prediction of rapid intensification**?

Minamide & Zhang (2017,2018); Zhang et al. (2016, 2018)



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PSU DA system of all-sky satellite radiances

Model: **WRF** ver.3.6.1(Skamarock 2008), **CRTM** (Han et al. 2006)

Advanced PSU WRF-EnKF (APSU) DA system
(Weng and Zhang, 2016; Zhang, Minamide and Clothiaux, 2016)

Ensemble-based data assimilation system: (60 members)

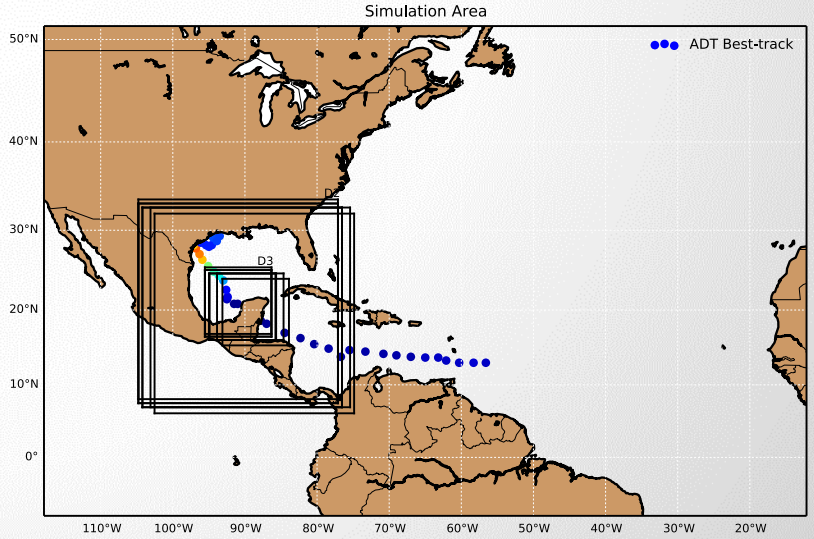
Regional convective-permitting model: (27, 9 & 3 km)

Error modeling

- Adaptive Observation Error Inflation (AOEI)
  (Minamide and Zhang, 2017, MWR)
- Adaptive Background Error Inflation (ABEI)
  (Minamide and Zhang, 2019, QJRMS)

Observations (hourly)

- All-sky GOES-16 channel 8 brightness temperatures
- Best-track minimum SLP



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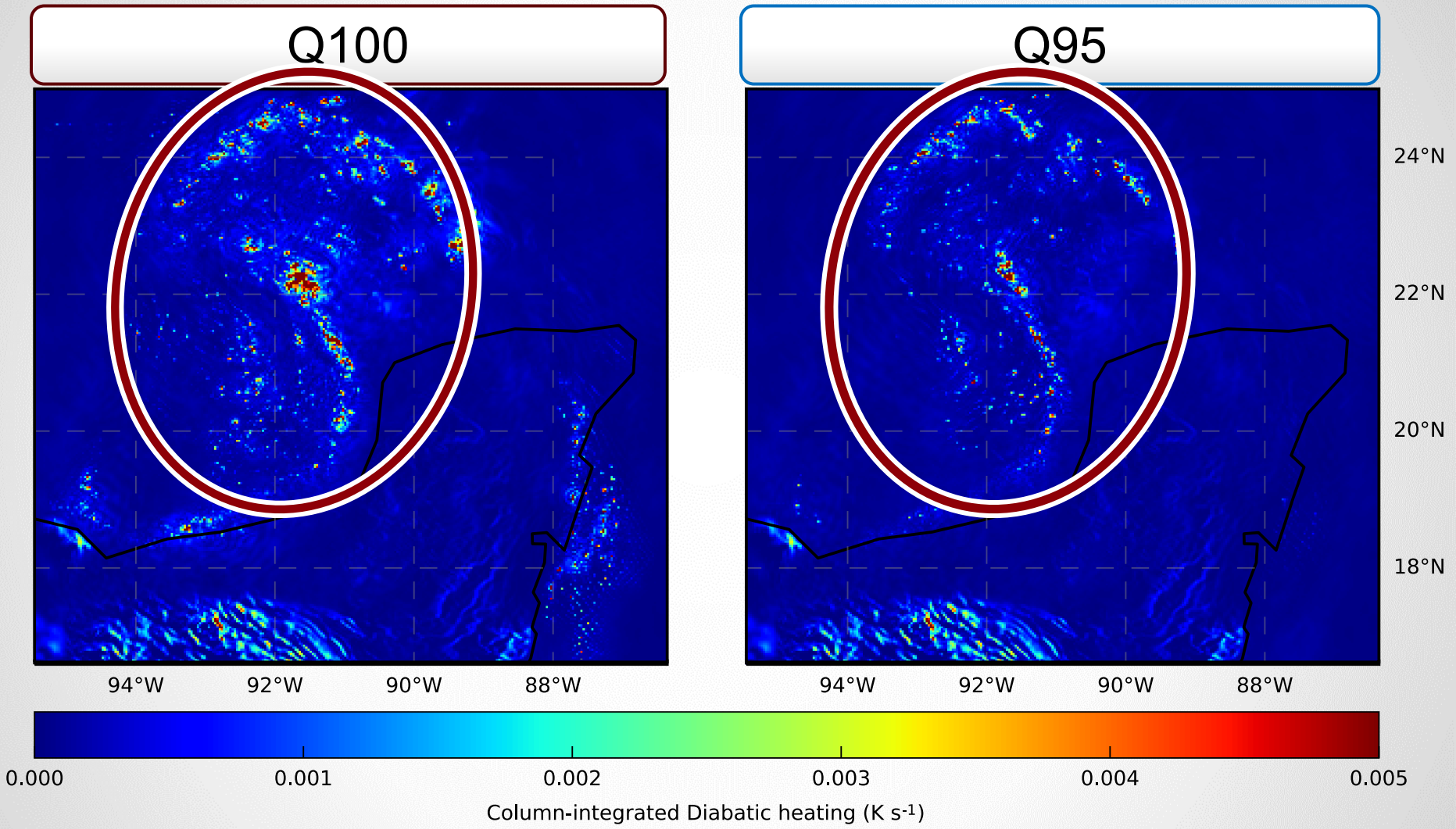
How much can **constrained convective activity** contribute to the **prediction of rapid intensification**?

- **Sensitivity experiments** to the strength of convections through modifying moisture initialization:
  - CNTL: PSU EnKF analysis of Hurricane Harvey (2017)
  - same vortex, but different moistures
  - Moistures within 600-km radius from TC center are reduced to modify convective activity

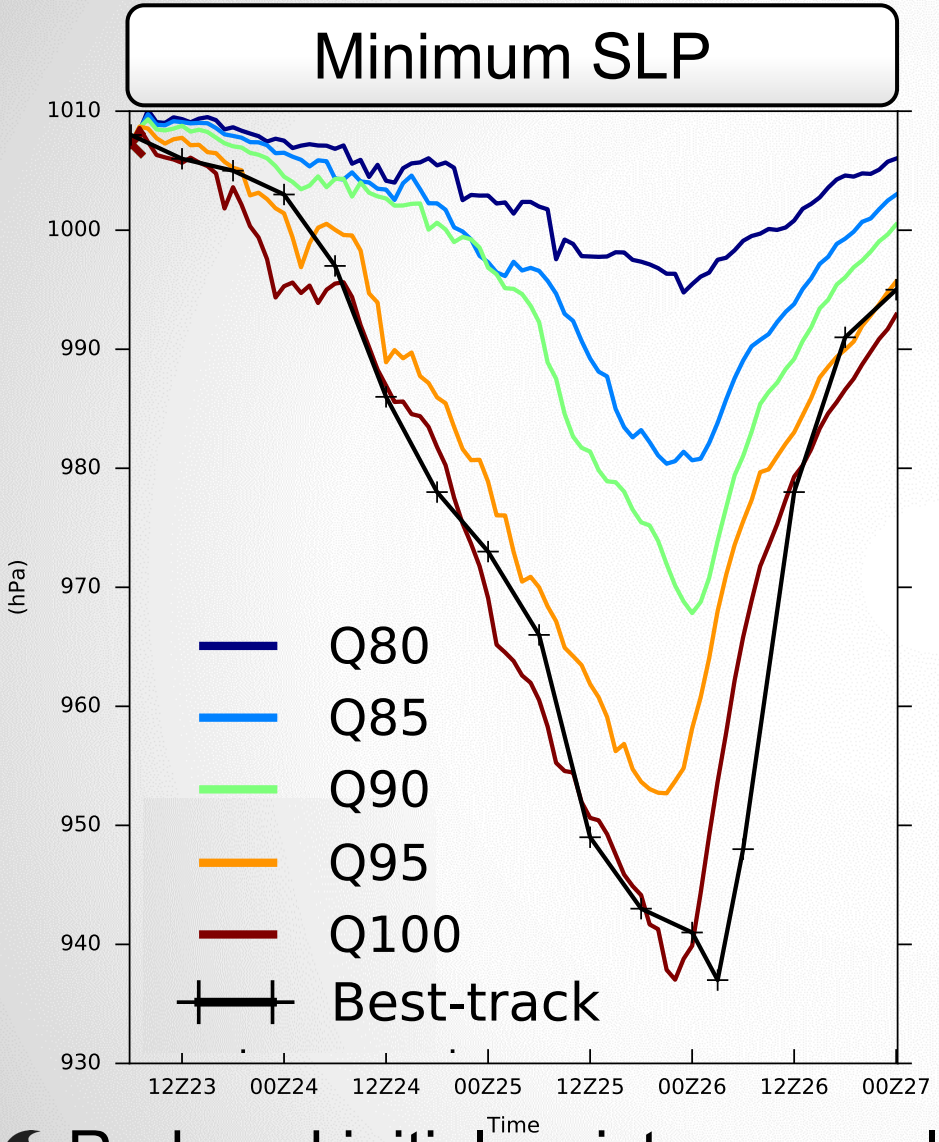
Experiment name	Q80	Q85	Q90	Q95	Q100
Moisture reduction	20 %	15 %	10 %	5 %	0 % (CNTL)

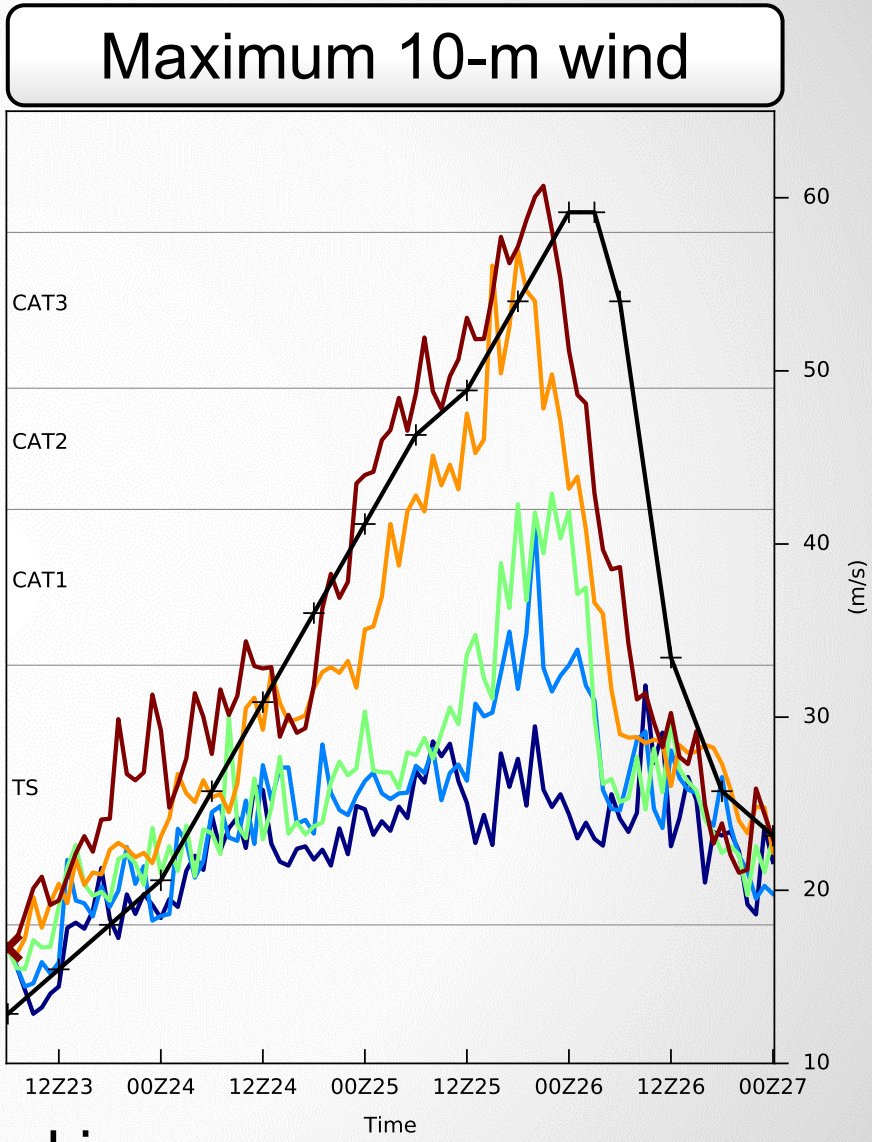
Spatial distribution of positive diabatic heating



- Reduced initial moistures resulted in similarly-horizontally-distributed but weaker convective activity.

Temporal evolution of TC intensity

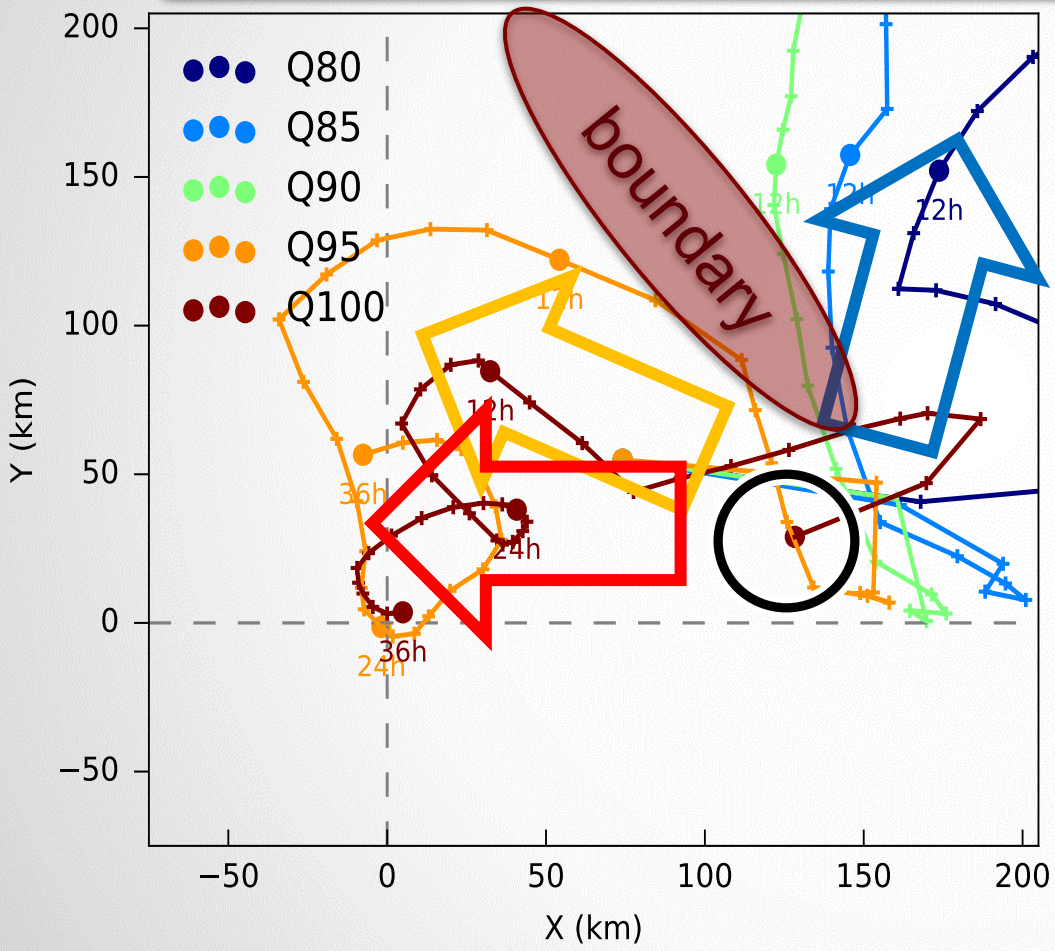




- Reduced initial moistures resulted in the delay or the failure of simulating the onset of RI

Impacts on precession process

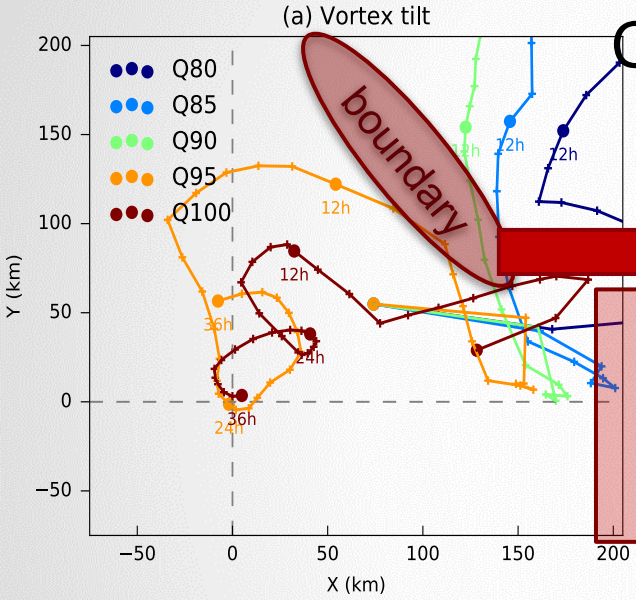
Temporal evolution of vortex tilt (precession)



- More moistures
  → stronger convections
  → earlier completion of precession process & smaller tilt-magnitude.
- There is a boundary between vortex solutions that are capable of completing the precession process vs. those that cannot.

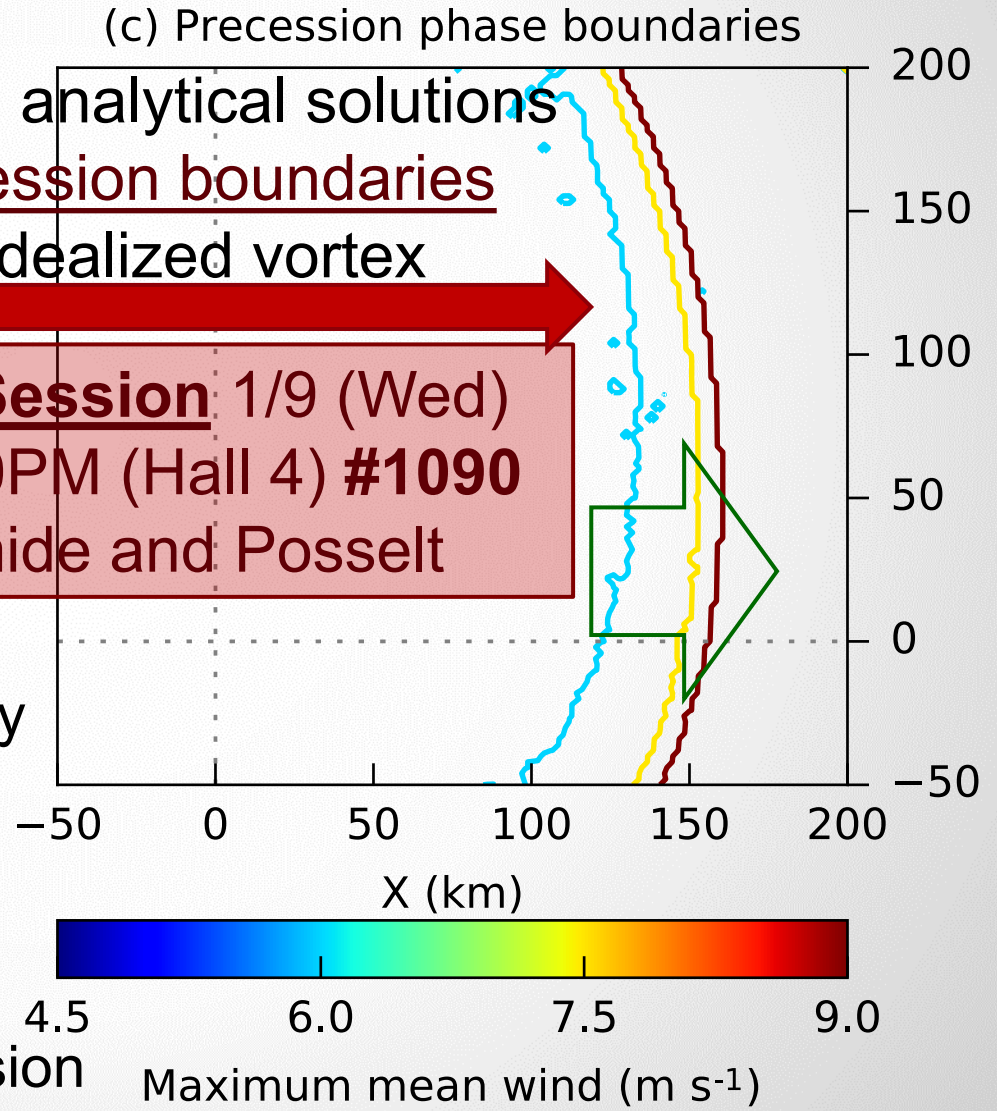
Impacts on precession process

Boundary-dependence on vortex strength



Calculated analytical solutions of precession boundaries with idealized vortex

Poster Session 1/9 (Wed)
4:00-6:00PM (Hall 4) **#1090**
Minamide and Posselt



- Boundary becomes further away from TC center with stronger vortex:
  → intensification of vortex increases resilience
  → helps completion of precession

Concluding Remarks

Summary:

- It is indicated that the onset of Rapid Intensification (RI) of TCs are sensitive to moisture initializations.
  - More moisture → more convection → more latent heating → more resilient vortex to adverse environmental wind shear → easier completion of precession.
- Analytical solution on the directions of precession process with idealized vortex will be demonstrated (poster session).

Poster Session 1/9 (Wed) 4:00-6:00PM (Hall 4) **#1090**
Minamide and Posselt
Tropical Cyclones and Extreme Monsoon Precipitation session

Future plan:

- Sensitivity of precession on the variations of convective activity
  - *where* and *how strong* convections are required
  - which TCs are easy/difficult to predict?

Thank you for your attention. (Masashi.Minamide@jpl.nasa.gov)